

In re Patent Application of:

SHIEH ET AL.

Serial No. 10/629,173

Filed: JULY 29, 2003

IN THE CLAIMS

1. (currently amended) A method of fabricating a long-wavelength vertical cavity surface emitting laser comprising the steps of:

depositing a long wave-length active region on a compatible substrate, the long wave-length active region having a first major surface;

depositing a first mirror stack on the first major surface of the long wave-length active region so as to define a major surface of the first mirror stack;

affixing a supporting substrate to the major surface of the first mirror stack;

removing the compatible substrate to expose an opposed second major surface of the long wave-length active region;
and

depositing a second mirror stack on the second major surface of the long wave-length active region;

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wherein the step of depositing the long wave-length
active region on the compatible substrate includes epitaxially
growing an indium phosphide based active region on an indium
phosphide based substrate.

2. (Currently Canceled)

3. (original) A method of fabricating a long-wavelength vertical cavity surface emitting laser as claimed in claim 1 wherein the step of depositing the first mirror stack includes depositing layers of material with good thermal conductivity.

4. (original) A method of fabricating a long-wavelength vertical cavity surface emitting laser as claimed in claim 1 wherein the step of depositing layers of material with good thermal conductivity includes depositing layers of material with a thermal conductivity comparable to a lattice matched semiconductor distributed Bragg reflector.

5. (Currently Canceled)

6. (currently amended) A method of fabricating a long-
wavelength vertical cavity surface emitting laser comprising
the steps of:

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depositing a long wave-length active region on a compatible substrate, the long wave-length active region having a first major surface;

depositing a first mirror stack on the first major surface of the long wave-length active region so as to define a major surface of the first mirror stack;

affixing a supporting substrate to the major surface of the first mirror stack;

removing the compatible substrate to expose an opposed second major surface of the long wave-length active region;
and

depositing a second mirror stack on the second major surface of the long wave-length active region;

wherein the step of depositing a first mirror stack includes metamorphically growing a distributed Bragg reflector on the first major surface of the long wave-length active region; and
~~A method of fabricating a long-wavelength vertical-cavity surface emitting laser as claimed in claim 5 wherein~~

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the step of metamorphically growing a distributed Bragg reflector includes metamorphically growing alternate layers of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ and $\text{Al}_y\text{Ga}_{1-y}\text{As}$, where x is in a range of from approximately 0.5 to 1 and y is in a range of from approximately 0 to 0.5.

7. (original) A method of fabricating a long-wavelength vertical cavity surface emitting laser as claimed in claim 6 wherein the step of metamorphically growing alternate layers of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ and $\text{Al}_y\text{Ga}_{1-y}\text{As}$ includes growing an AlAs/GaAs distributed Bragg reflector on an InP long wave-length active region.

8. (original) A method of fabricating a long-wavelength vertical cavity surface emitting laser as claimed in claim 1 wherein the step of affixing the supporting substrate to the major surface of the first mirror stack includes bonding a supporting substrate approximately thermal-expansion matched to the first mirror stack.

9. (original) A method of fabricating a long-wavelength vertical cavity surface emitting laser as claimed in claim 8 wherein the step of bonding a supporting substrate includes bonding a mechanical InP substrate to the first mirror stack.

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10. (Currently Canceled)

11. (currently amended) A method of fabricating a long-wavelength vertical cavity surface emitting laser comprising the steps of:

depositing a long wave-length active region on a compatible substrate, the long wave-length active region having a first major surface;

depositing a first mirror stack on the first major surface of the long wave-length active region so as to define a major surface of the first mirror stack;

affixing a supporting substrate to the major surface of the first mirror stack;

removing the compatible substrate to expose an opposed second major surface of the long wave-length active region; and

depositing a second mirror stack on the second major surface of the long wave-length active region;

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wherein the step of affixing the supporting substrate to the major surface of the first mirror stack includes depositing a supporting layer of heat conducting material on the major surface of the first mirror stack; and

~~A method of fabricating a long-wavelength vertical cavity surface emitting laser as claimed in claim 10~~

wherein the supporting layer of heat conducting material is not thermal-expansion matched to the compatible substrate.

12. (currently amended) A method of fabricating a long-wavelength vertical cavity surface emitting laser as claimed in claim 11, wherein the step of depositing the supporting layer of heat conducting material on the major surface of the first mirror stack includes depositing metal.

13. (original) A method of fabricating a long-wavelength vertical cavity surface emitting laser as claimed in claim 12 wherein the step of depositing metal includes depositing one of copper, silver, gold, nickel, and aluminum.

14. (original) A method of fabricating a long-wavelength vertical cavity surface emitting laser as claimed in claim 1 wherein the step of depositing the second mirror stack

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includes depositing one of a distributed Bragg reflector and a dielectric mirror stack.

15. (original) A method of fabricating a long-wavelength vertical cavity surface emitting laser as claimed in claim 14 wherein the step of depositing the second mirror stack includes depositing layers of material with good temperature conductivity.

16. (currently amended) A method of fabricating a long-wavelength vertical cavity surface emitting laser comprising the steps of:

depositing a long wave-length active region on a compatible substrate, the long wave-length active region having a first major surface;

depositing a first mirror stack on the first major surface of the long wave-length active region so as to define a major surface of the first mirror stack;

affixing a supporting substrate to the major surface of the first mirror stack;

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removing the compatible substrate to expose an opposed second major surface of the long wave-length active region;

depositing a second mirror stack on the second major surface of the long wave-length active region; and

~~A method of fabricating a long-wavelength vertical cavity surface emitting laser as claimed in claim 1 including in addition a step of~~

forming a light inlet opening through the supporting substrate for optically pumping the long-wavelength vertical cavity surface emitting laser.

17. (currently amended) A method of fabricating a long-wavelength vertical cavity surface emitting laser comprising the steps of:

depositing a long wave-length active region on a compatible substrate, the long wave-length active region having a first major surface;

depositing a first mirror stack on the first major surface of the long wave-length active region so as to define a major surface of the first mirror stack;

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affixing a supporting substrate to the major surface of the
first mirror stack;

removing the compatible substrate to expose an opposed second
major surface of the long wave-length active region;

depositing a second mirror stack on the second major surface
of the long wave-length active region; and

~~A method of fabricating a long-wavelength vertical cavity-~~
~~surface emitting laser as claimed in claim 1 including in-~~
~~addition a step of~~

forming at least one of the long wave-length active region and
the second mirror stack to provide index guiding for the long-
wavelength vertical cavity surface emitting laser.

18. (original) A method of fabricating a long-wavelength
vertical cavity surface emitting laser comprising the steps
of:

depositing an InP based long wave-length active region on an
InP based substrate, the long wave-length active region having
a first major surface;

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depositing a metamorphic distributed Bragg reflector on the first major surface of the long wave-length active region so as to define a major surface of the distributed Bragg reflector;

affixing a supporting substrate to the major surface of the distributed Bragg reflector;

removing the InP based substrate to expose an opposed second major surface of the long wave-length active region; and

depositing a second mirror stack on the second major surface of the long wave-length active region.

19. (original) A method of fabricating a long-wavelength vertical cavity surface emitting laser as claimed in claim 18 wherein the step of depositing a metamorphic distributed Bragg reflector includes depositing alternate layers of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ and $\text{Al}_y\text{Ga}_{1-y}\text{As}$, where x is in a range of from approximately 0.5 to 1 and y is in a range of from approximately 0 to 0.5.

20. (original) A method of fabricating a long-wavelength vertical cavity surface emitting laser as claimed in claim 18 wherein the step of depositing a metamorphic distributed Bragg

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reflector includes depositing alternate layers of micro-crystalline silicon and micro-crystalline silicon carbide.

21. (original) A method of fabricating a long-wavelength vertical cavity surface emitting laser as claimed in claim 18 wherein the step of depositing a metamorphic distributed Bragg reflector includes depositing alternate layers of micro-crystalline silicon and micro-crystalline aluminum oxide.

22. (original) A method of fabricating a long-wavelength vertical cavity surface emitting laser as claimed in claim 18 wherein the step of affixing the supporting substrate includes affixing one of a supporting layer of heat conducting material and an InP based substrate.

23. (original) A method of fabricating a long-wavelength vertical cavity surface emitting laser as claimed in claim 18 wherein the step of affixing the supporting layer of heat conducting material includes plating metal.

24. (original) A method of fabricating a long-wavelength vertical cavity surface emitting laser as claimed in claim 23 wherein the step of plating metal includes plating one of copper, silver, gold, nickel, and aluminum.

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25. (original) A method of fabricating a long-wavelength vertical cavity surface emitting laser as claimed in claim 18 wherein the step of depositing the second mirror stack includes depositing one of a metamorphic distributed Bragg reflector and a dielectric mirror stack.